



8086 Flag Register

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Lecture References:

□ **Book:**

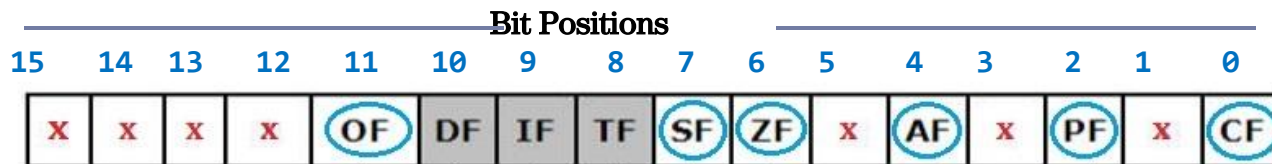
- *Microprocessors and Interfacing: Programming and Hardware,*
*Chapter # 2, **Author:** Douglas V. Hall*

8086 Flag Register

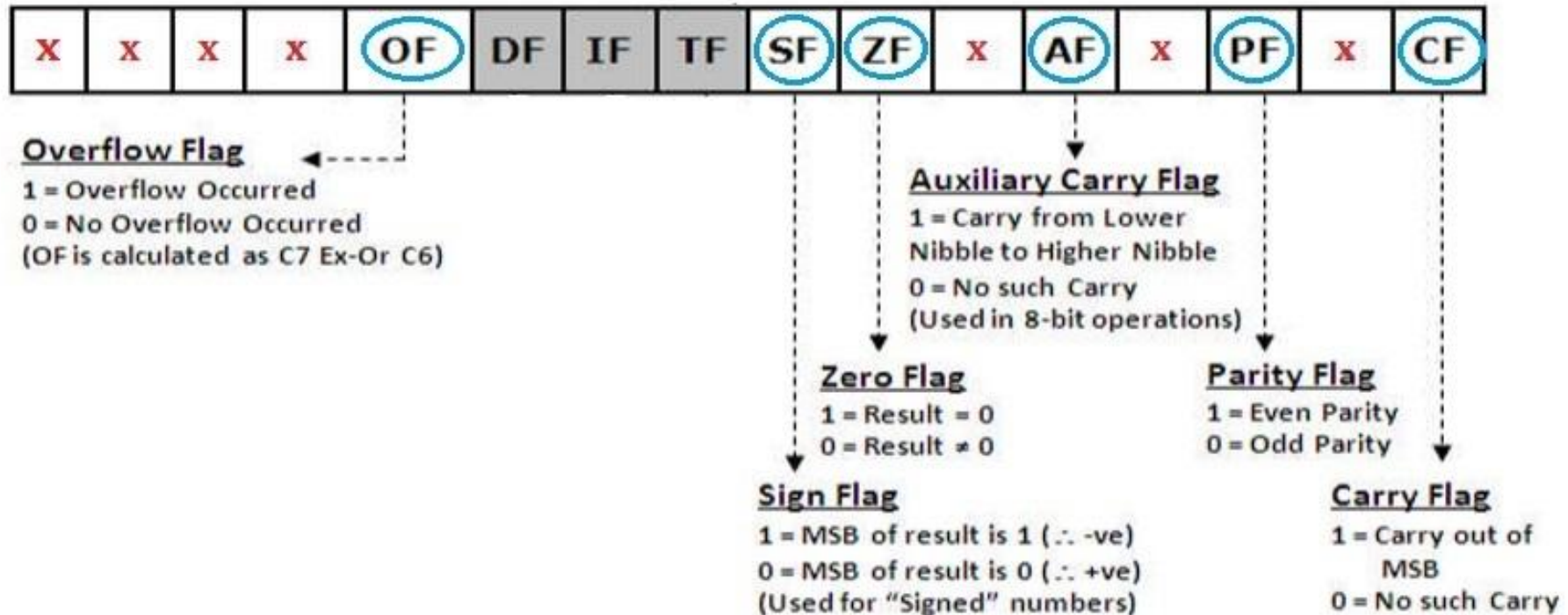
□ 16-Bit register

- **7 bits are undefined/unused (marked by red x in the figure below)**
- **6 status/condition flags (marked by blue circles)**
- **3 control flags (those in grey boxes)**

- The condition flags are set (1) or reset (0) depending on the result of an arithmetic/logical operation.
- Control flags control the operations of the CPU



Status Flags



Flags are useful in programming e.g. when writing conditions such as:

- If answer is zero, do ... else // zero flag comes in hand here
- If answer is less than zero, do ... else // sign flag can be used here

Status Flags

□ **Zero Flag (ZF)** → **1** if the *answer* is exactly zero.
0 if the *answer* is not exactly zero.

□ **Parity Flag (PF)** → **1** if the count of 1s in the *answer* is **EVEN**
0 if the count of 1s in the *answer* is **ODD**

* NB: If there is no 1s (number of 1s is zero) in the ans, then parity flag is

□ **Sign Flag (SF)** → **1** if the msb in the *ans* is 1 (negative number)
0 if the msb in the *ans* is 0 (positive number)

Be Careful

If we add two n bits numbers and we get an answer of $(n+1)$ bits ,

We have to *consider the lowest n bits* in the answer.

Table for consideration:

	8 Bit Register	16 bit Register
SF	Lowest 8	Lowest 16
ZF	Lowest 8	Lowest 16
PF	Lowest 8	Lowest 8

Status Flags

- ❑ **Auxiliary Flag (AF)** → **1** if there is **UNSIGNED** overflow from lower nibble. Otherwise **0**.
- ❑ **Carry Flag (CF)** - is set to '1' when there is an unsigned overflow. E.g. when you add bytes 255 + 1 (result is not in range 0...255). When there is no overflow this flag is reset to 0.
- ❑ **Overflow Flag (OF)** - set to '1' when there is a signed overflow. For example, when you add bytes 100 + 50. (see next slide)

Overflow Flag

1 → **ONLY** carry from 2nd last msb to last msb **OR**
ONLY carry from last msb to beyond msb (1 bit left of
msb)

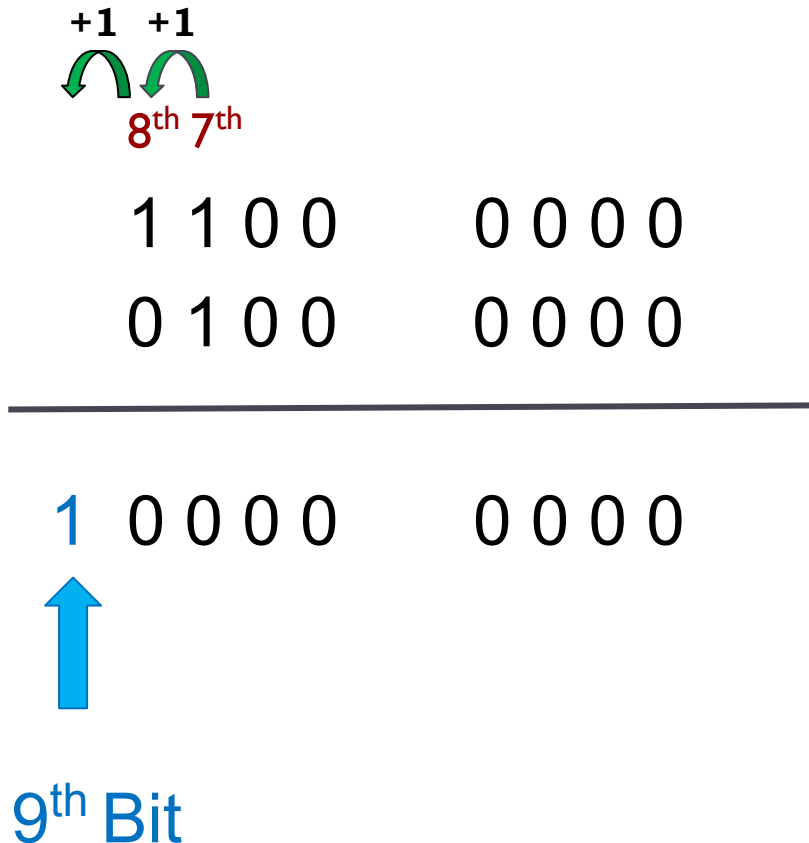
0 → **Both carry** from 2nd last msb to last msb AND
carry from last msb to beyond msb. **OR**

No Carry from 2nd last msb to last msb AND also
No carry from last msb to beyond msb

Status Flags

- ❑ **Auxiliary Flag (AF)** - set to '1' when there is an unsigned overflow for low nibble (4 bits).
- ❑ **Carry Flag (CF)** - is set to '1' when there is an unsigned overflow. E.g. when you add bytes $255 + 1$ (result is not in range $0...255$). When there is no overflow this flag is reset to 0.
- ❑ **Overflow Flag (OF)** - set to '1' when there is a signed overflow.
For example, when you add bytes $100 + 50$. (see next slide)

Overflow Flag (OF) Example



2nd Last MSB = 7^{th}

Last MSB = 8^{th}

Beyond MSB = 9^{th}

CF = 1

OF = 0

Status Flags

NB:

OF is set to 1 if there is a carry from:

- the 7th bit to the 8th bit ONLY or
- from the 8th bit to the 9th bit ONLY

If there is a carry from the 7th bit to the 8th bit and from the 8th bit to the 9th bit at THE SAME TIME then OF = 0

OF=1

Set because there is a carry from the 7th bit to the 8th bit ONLY

AF=0

Reset because there is NO carry from the lower nibble to the upper nibble

MOV AL, 50h (0 1 0 1 0 0 0 0)

MOV BL, 32h (0 0 1 1 0 0 1 0)

ADD AL, BL (1 0 0 0 0 0 1 0)

CF=0

Reset because the answer has NO carry

SF=1

Set because the MSB is 1 indicating a negative answer

ZF=0

Reset because the answer is NOT zero

PF=1

Set because the answer has an EVEN number of 1s

Status Flags

NB:

OF is reset to 0 if:

- there is a carry from the 7th bit to the 8th bit and from the 8th bit to the 9th bit at THE SAME TIME or
- there is NO carry from the 7th bit to the 8th bit and from the 8th bit to the 9th bit at THE SAME TIME

OF=0

Reset because there is a carry from the 7th bit to the 8th bit and from the 8th bit to the 9th bit at THE SAME TIME

Carry

1 1 1 1 1 1 1 1

AF=1

Set because there IS a carry from the lower nibble to the upper nibble

□ MOV AL, FFh

1 1 1 1 1 1 1 1

□ MOV BL, 01h

0 0 0 0 0 0 0 1

□ ADD AL, BL

1 0 0 0 0 0 0 0

CF=1

Set because the answer has a carry

SF=0

Reset because the MSB is 0 indicating a positive answer

ZF=1

Set because the answer IS zero

PF=1

Set because the answer has an EVEN number of 1s

Question

- Let's say we are adding two numbers of n digits. The resultant is $(n+1)$. The carry flag is always 1.
(True / False)
- Will the carry flag and overflow flag value be always opposite. (Yes / No)

OF and CF flags are **INDEPENDENT**

$\begin{array}{r} \overset{+1}{\curvearrowright} \\ 0100 \ 0000 \\ + 0100 \ 0000 \\ \hline 1000 \ 0000 \end{array}$ <p>OF = 1 CF = 0</p>	$\begin{array}{r} \overset{+1}{\curvearrowright} \\ 1000 \ 0000 \\ + 1000 \ 0000 \\ \hline 10000 \ 0000 \\ \uparrow 9^{\text{th}} \text{ bit} \end{array}$ <p>OF = 1 CF = 1</p>	$\begin{array}{r} \overset{+1}{\curvearrowright} \quad \overset{+1}{\curvearrowright} \\ 1100 \ 0000 \\ + 0100 \ 0000 \\ \hline 10000 \ 0000 \\ \uparrow 9^{\text{th}} \text{ bit} \end{array}$ <p>OF = 0 CF = 1</p>	$\begin{array}{r} \overset{+1}{\curvearrowright} \\ 1001 \ 0000 \\ + 0001 \ 0000 \\ \hline 1010 \ 0000 \end{array}$ <p>OF = 0 CF = 0</p>
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Control Flags:



Direction Flag ←
 1 = Auto Decrement
 0 = Auto Increment
 (Used in String Instructions)

Interrupt Flag ←
 1 = Enable Interrupt
 0 = Disable Interrupt
 (Affects Only INTR)

Trap Flag
 1 = Perform Single Stepping
 0 = Do Not Perform Single Stepping

Control Flags:

- ❑ **Trap Flag (TF)** - Used for on-chip single-step debugging.
- ❑ **Interrupt enable Flag (IF)** - when this flag is set to '1' CPU reacts to interrupts from external devices.
- ❑ **Direction Flag (DF)** - this flag is used by some instructions to process data chains, when this flag is set to '0' - the processing is done forward, when this flag is set to '1' the processing is done backward.

Quiz: Status Flag Values?

- MOV AX, ABCDh
- MOV BX, 9876h
- ADD AX, BX

FFCDh

FFXYh

Given $PF = 0$ & $AF = 1$, Maximum value for XY

Given $PF = 0$ & $AF = 0$, Maximum value for XY

Given $PF = 1$ & $AF = 0$, Maximum value for XY

Given $PF = 1$ & $AF = 1$, Maximum value for XY

Thank You !!

